

*the technical note technn*

AD-A283 963

23-Gigahertz (GHz) Digital Low Density Radio Communications Link (LDRCL) Operational Test and Evaluation (OT&E) Integration and OT&E Operational Final Test Report

Michael R. Melillo

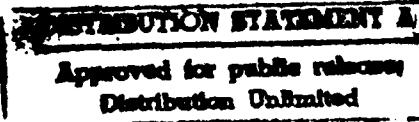


August 1994

DOT/FAA/CT-TN94/27

Document is on file at the Technical Center Library,  
Atlantic City International Airport, NJ 08405.

U.S. Department of Transportation  
Federal Aviation Administration  
Technical Center  
Atlantic City Airport, NJ 08405



94-27428



35P8

DTIC QUALITY IMPROVED 1

8 25 214

**Best  
Available  
Copy**

## **NOTICE**

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for the contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
DOT/FAA/CT-TN94/27			
4. Title and Subtitle <b>23-GIGAHERTZ (GHz) DIGITAL LOW DENSITY RADIO COMMUNICATIONS LINK (LDRCL) OPERATIONAL TEST AND EVALUATION (OT&amp;E) INTEGRATION AND OT&amp;E OPERATIONAL FINAL TEST REPORT</b>		5. Report Date August 1994	
7. Author(s) Michael R. Melillo		6. Performing Organization Code	
9. Performing Organization Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		8. Performing Organization Report No. DOT/FAA/CT-TN94/27	
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS)	
15. Supplementary Notes		11. Contract or Grant No.	
		13. Type of Report and Period Covered Technical Note	
		14. Sponsoring Agency Code	
16. Abstract			
<p>This report contains the results of the Operational Test and Evaluation (OT&amp;E) Integration and OT&amp;E Operational Testing of the Commercial-Off-The-Shelf (COTS) Low Density Radio Communications Link's (LDRCL) 23-gigahertz (GHz) digital radio system. The OT&amp;E testing was accomplished by first testing the LDRCL equipment against its equipment specification (FAA-E-2853A), and then performing OT&amp;E testing at the key site (Keller, Texas). These tests proved that the 23-GHz LDRCL equipment can fulfill its mission in the National Airspace System (NAS) and that it is suitable and effective.</p> <p>Based on the test results, it is concluded that the 23-GHz LDRCL equipment is qualified for operational deployment.</p>			
17. Key Words Low Density Radio Communications Link (LDRCL) 23-GHz Digital Radio System	18. Distribution Statement Document is on file at the Technical Center Library, Atlantic City International Airport, NJ 08405		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 34	22. Price

## TABLE OF CONTENTS

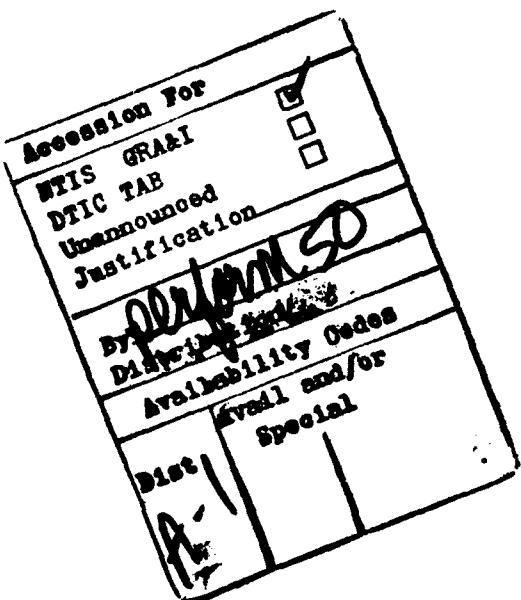
	Page
<b>EXECUTIVE SUMMARY</b>	<b>v</b>
<b>1. INTRODUCTION</b>	<b>1</b>
1.1 Background	1
1.2 Purpose	1
1.3 Participants	1
1.4 Reference Documents	2
<b>2. TEST APPROACH AND CONCEPT</b>	<b>3</b>
<b>3. TESTS AT THE FAA TECHNICAL CENTER</b>	<b>4</b>
3.1 Operational User's Requirement Test Verification Requirements Traceability Matrix (TVRTM) Tests (Appendix B)	4
3.2 System Level/Integration Test Matrix Tests (Appendix C)	6
<b>4. OT&amp;E INTEGRATION TESTS AT KEY SITE</b>	<b>6</b>
4.1 FAA-E-2853A TVRTM Tests (Appendix A)	7
4.2 Operational User's Requirement TVRTM Tests (Appendix B)	7
4.3 System Level/Integration Matrix Tests (Appendix C)	8
<b>5. TEST RESULTS</b>	<b>9</b>
5.1 Test Results at the FAA Technical Center	9
5.2 OT&E Integration Test Results	9
<b>6. CONCLUSIONS</b>	<b>10</b>
6.1 Test Conclusions at the FAA Technical Center	10
6.2 Operational Test and Evaluation (OT&E) Integration Test Conclusions	11
<b>7. RECOMMENDATIONS</b>	<b>13</b>
<b>8. ACRONYMS AND ABBREVIATIONS</b>	<b>14</b>
<b>APPENDIXES</b>	
A - FAA-E-2853A Test Verification Requirements Traceability Matrix (TVRTM)	
B - Operational User's Requirements Test Verification Requirements Traceability Matrix (TVRTM)	
C - System Level/Integration Test Matrix	

## LIST OF ILLUSTRATIONS

Figure		Page
1	LDRCL 23-GHz Digital Subsystem Test Configuration	3
2	Typical NAS System Level Block Diagram	5
3	Subsystem Block Diagram	5
4	Typical NAS System Block Diagram	7

## LIST OF TABLES

Table		Page
1	23-GHz Digital System Equipment	4



## **EXECUTIVE SUMMARY**

This test report describes the results of the Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing performed on the Low Density Radio Communications Link (LDRCL) 23-gigahertz (GHz) digital radio system installed at the Keller, Texas, Air Route Surveillance Radar (ARSR) site. The OT&E effort was conducted by Federal Aviation Administration (FAA) Technical Center personnel during the period of February 10 through 18, 1994.

The LDRCL is comprised of nondevelopment items (NDI) from the manufacturers listed below and integrated into the LDRCL system by Alcatel Communications and Government Systems of Richardson, Texas.

<u>ITEM</u>	<u>MANUFACTURER</u>
MicroNet 23 Digital Radio	Microwave Networks, Inc.
Digital Channel Bank	Wescom
Battery/Charger	Power Conversion Products (PCP)
Remote Alarm	Westronic

During testing at the FAA Technical Center and the Keller, Texas, test site, it was found that this equipment did not meet all of the FAA-E-2853A specifications. It must be noted that this equipment is NDI and was not specifically designed to meet all of the 23-gigahertz (GHz) LDRCL requirements. FAA Order 1810.6, Policy for Use of Nondevelopmental Items (NDI) in FAA Acquisitions, allows for the deployment of NDI equipment that does not meet all specification requirements, provided the equipment is operationally effective and suitable prior to commissioning of the subsystem.

The following areas are of concern:

1. The LDRCL equipment when equipped with Total Harmonic Distortion (THD) filters meets all of the requirements in Order 6950.2C for the critical alternating current (A/C) power bus with the exception of the time requirement for the in-rush current to return to 110 percent of its normal value.
2. Without THD filters, this equipment exceeds the THD requirement for the input current for equipment connected to the critical AC power bus.
3. Radio Frequency Interference (RFI) filtering must be added to the power connections to the Westronics Alarm System.
4. A sensing circuit must be added to indicate when the Low Voltage Battery Disconnect (LVBD) has failed.

In response to our concerns, the program office has agreed to install THD filters in all systems that will be connected to the critical power bus and add a RFI filter to the Westronic Alarm System. A Engineering Change Proposal (ECP) is being prepared to resolve the LVBD failure problem. The program office will request a waiver for the in-rush current time specification contained in Order 6950.2C so that LDRCL could be connected to the critical AC power bus.

Deployment is recommended with the conditions noted in section 7 of this report.

## 1. INTRODUCTION.

This report describes the results of the Low Density Radio Communications Link (LDRCL) Operational Test and Evaluation (OT&E) Integration and OT&E Operational testing performed in Keller, Texas, and at the Federal Aviation Administration (FAA) Technical Center. The testing was performed in Keller, Texas, during the period of February 10 through February 18, 1994, with additional testing performed at the FAA Technical Center to reverify test data or complete testing that could not be performed at the key site.

### 1.1 BACKGROUND.

The LDRCL procurement (Specification FAA-E-2853A) will provide equipment to replace and upgrade existing links, leased systems, and new requirements for data communications for various National Airspace System (NAS) plan projects implemented in 1990 and beyond. Some of the current links that will be replaced are the short haul user access links and leased lines remoting circuits which currently provide connections between operational facilities such as Air Traffic Control Towers (ATCT), Terminal Radar Approach Control (TRACON), and remote sites such as Remote Communications Air-to-Ground Facility (RCAG), Air Route Surveillance Radar (ARSR), Airport Surveillance Radar (ASR) and others.

### 1.2 PURPOSE.

The purpose of this report is to describe the OT&E Integration and OT&E Operational testing performed on the 23-gigahertz (GHz) digital radio system and ACW-400A's reasons for recommending deployment of the system, at this time.

### 1.3 PARTICIPANTS.

<u>NAME</u>	<u>ORGANIZATION</u>
Wayne Bell	FAA Technical Center (APMT)
Michael R. Melillo	FAA Technical Center (Lead LDRCL project engineer) ACW-400A
Fritz Chey	Martin Marietta
Trinh Do	FAA (TOR)
Dan Smith	Alcatel
Rick Daugherty	Alcatel
Herman Rigdon	Alcatel

#### 1.4 REFERENCE DOCUMENTS.

##### FAA Specifications

FAA-G-2100E                    Electronic Equipment, General Requirements  
FAA-E-2853A                    Low Density Radio Communications Link Specification

##### FAA Standards

FAA-STD-024A                   Preparation of Test and Evaluation Documentation  
FAA-STD-028                    NAS Training Guidelines  
FAA-STD-013/016/018           Quality Control Program Requirements  
FAA-STD-021                    Configuration Management  
FAA-STD-020A                   Transient Protection, Grounding, Bonding and  
                                  Shielding Requirements for Equipment

##### FAA Orders

1810.4B                      FAA NAS Test & Evaluation Program  
1810.6                        Policy for use of Nondevelopmental Items (NDI)  
                                  in FAA Acquisitions  
OAP 8200.1                    U.S. Standard Flight Inspection Manual  
6000.3                        Maintenance of FAA Communications System  
6950.2C                      Electrical Power Policy Implementation at  
                                 National Airspace Facilities

##### NAS Documents

NAS-SS-1000  
Volume I                      NAS System Specification, Functional and  
                                  Performance Requirements for the National  
                                  Airspace System, General  
  
NAS-SS-1000  
Volume III                    NAS System Specification, (Ground to Air  
                                 Element)  
  
NAS-SS-1000  
Volume I                      National Airspace System, System Requirements  
                                 Specification  
  
NAS-MD-110                    NAS Test Terms and Definitions  
  
NAS-IR-44010001              Digital Interface Requirements  
  
NAS-IR-44010002              Analog Interface Requirements

## Other Documents

ISO-7498	Open Systems Interconnection Standards (Information Processing System)
EIA RS-195	Electrical and Mechanical Characteristics of Microwave Relay System Antennas and Passive Reflectors
PUB 62411	Accunet T1.5 Service Description and Interface Specifications
Bell Labs	American Digital Hierarchy
International Radio Consultative Committee:	Radio-Frequency Channel Arrangements for Radio Relay Systems
CCIR REC 283-4	
CCIR REC 275-3	Pre-Emphasis Characteristics for Frequency Modulation Radio-Relay Systems for Telephony using FM Multiplexing

## 2. TEST APPROACH AND CONCEPT.

The test approach and concept was to evaluate the LDRCL equipment in accordance with the Low Density Radio Communications Link (LDRCL) Master Test Plan and the Low Density Radio Communications Link (LDRCL) Operational Test and Evaluation (OT&E) Integration and Operational Test Plan. This involved testing the requirements contained in the LDRCL Specification FAA-E-2853A associated with the 23-GHz radio system which are contained in appendix A of this document, the NAS-SS-1000 Operational User's Requirements which are contained in appendix B of this document, and requirements contained in the System Level/Integration Test Matrix contained in appendix C of this document.

The LDRCL subsystem used for the OT&E Integration and OT&E Operational tests was comprised of terminal equipment at the Keller ARSR and Radio Communications Link Repeater (RCLR). A block diagram of the test configuration is provided in figure 1 and a list of the equipment that was tested at Keller and/or the FAA Technical Center is listed in table 1.

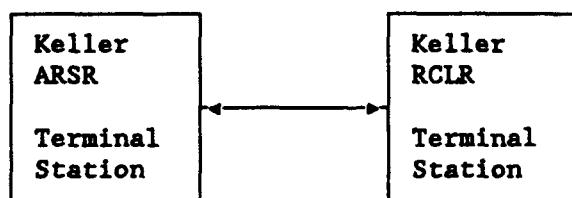


FIGURE 1. LDRCL 23-GHz DIGITAL SUBSYSTEM TEST CONFIGURATION

TABLE 1. 23-GHz DIGITAL SYSTEM EQUIPMENT

Equipment	Terminal 1	Terminal 2
Micronet 23 Digital Radio	Qty 1	Qty 1
DS1 Crossconnect	Qty 1	Qty 1
Wescom Channel Bank (Redundant)	Qty 1	Qty 1
Westronic Alarm System	Qty 1	Qty 1
202T modem for above	Qty 1	N/A
24-channel jackfields	Qty 1	Qty 1
Standalone Fault Monitor	N/A	N/A
Modem for above	N/A	N/A
Battery Charger System	Qty 1	Qty 1
4 Wire E&M VF cards	Qty 2	Qty 2
4 wire E&M E/R cards	Qty 24	Qty 24
Transmission Only E/R cards	Qty 1	Qty 1

### 3. TESTS AT THE FAA TECHNICAL CENTER.

The testing done at the FAA Technical Center was used to verify requirements that could not be tested in the field and reverify data collected in the field. The testing done at the FAA Technical Center was limited due to the late availability of the equipment at the center. The testing that was accomplished is listed in the following sections.

#### 3.1 OPERATIONAL USER'S REQUIREMENT TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX (TVRTM) TESTS (APPENDIX B).

##### 3.1.1 NAS System Level Tests.

These tests were run to evaluate that the LDRCL equipment can suitably and effectively interface with other NAS subsystems. Figure 2 is a typical NAS system level block diagram of the test configuration used. The Transmission Impairment Measuring Sets (TIMS) simulate users.

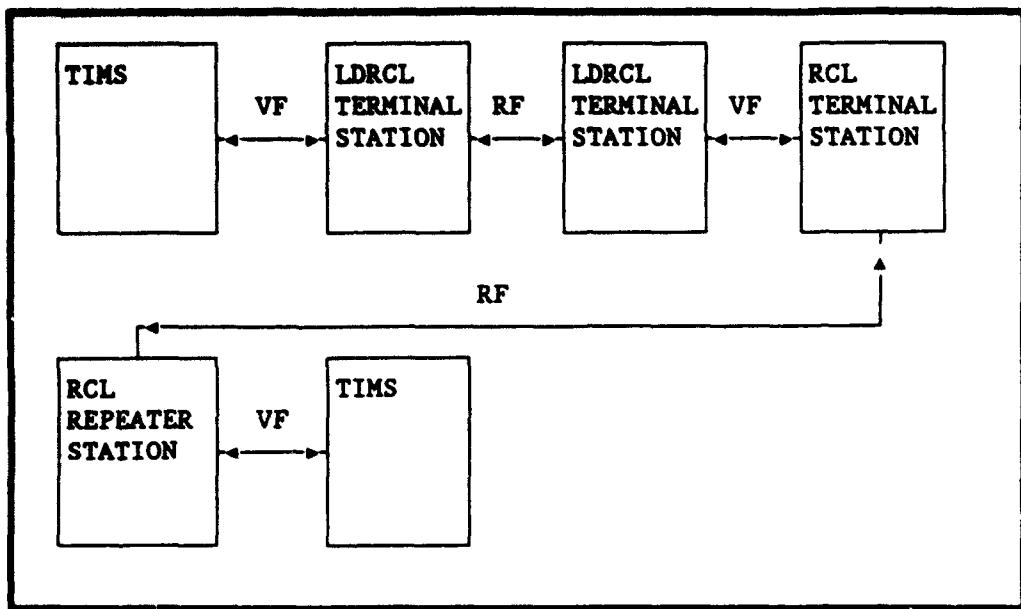


FIGURE 2. TYPICAL NAS SYSTEM LEVEL BLOCK DIAGRAM

The following NAS system level tests were run at the FAA Technical Center:

- a. Audio Quality Test - LDRCL to Radio Communications Link (RCL) (TVRTM test #1).
- b. LDRCL/RCL Critical Circuit Interface Test (TVRTM test #9).

### 3.1.2 Subsystem Level Tests.

These tests were run to see that the LDRCL subsystem met certain criteria established by the program office in the Master Test Plan (MTP). Figure 3 is a typical block diagram for a subsystem level test.

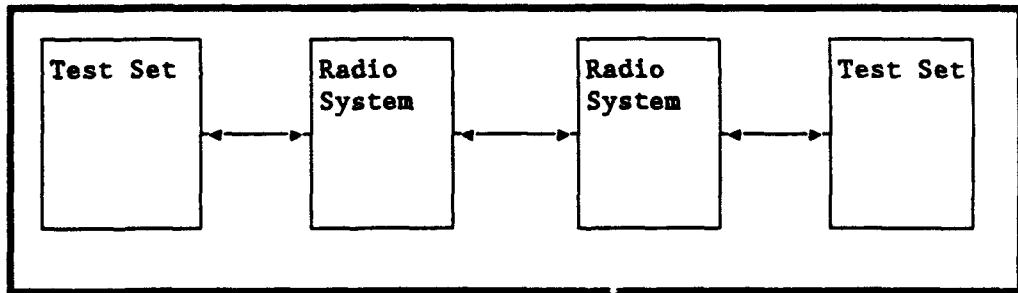


FIGURE 3. SUBSYSTEM BLOCK DIAGRAM

The following subsystem level tests were run at the FAA Technical Center:

- a. Crosstalk (TVRTM test #2),
- b. Alarms Indication Test during transients (TVRTM test #3),
- c. Maintainability Test (TVRTM test #4),
- d. Line Replaceable Unit (LRU) Removal/Replacement Test (TVRTM test #5),
- e. LDRCL Electromagnetic Interference (EMI)/Radio Frequency Interference (RFI) Test (TVRTM test #11).

### 3.2 SYSTEM LEVEL/INTEGRATION TEST MATRIX TESTS (APPENDIX C).

#### 3.2.1 NAS System Level Tests.

These tests were run to evaluate that the LDRCL equipment can suitably and effectively interface with other NAS subsystems. See figure 2 for a typical NAS system level block diagram of the test configuration used. The TIMS simulate users.

The following NAS system level tests were run at the FAA Technical Center:

- a. Modem to LDRCL Test,
- b. ANMS to LDRCL Interface Test,
- c. Total Harmonic Distortion Test,
- d. In-rush Current Test.

#### 3.2.2 Subsystem Level Tests.

These tests were run to see that the LDRCL subsystem met certain criteria established by the FAA Technical Center in the Low Density Radio Communications Link (LDRCL) Operational Test and Evaluation (OT&E) Integration and Operational Test Plan. Figure 3 is a typical block diagram for a subsystem level test.

The following subsystem level tests were run at the FAA Technical Center:

- a. Envelope Delay Distortion Test,
- b. Frequency Translation and Level Test,
- c. Channel Amplitude Frequency Response Test,
- d. Phase and Jitter Test,
- e. Voice Frequency Performance Test,
- f. Degraded Operations Test.

### 4. OT&E INTEGRATION TESTS AT KEY SITE.

Testing done at the key site is used to verify that the new subsystem can be successfully installed and operated at a NAS operation site. These tests were run to evaluate that the LDRCL equipment can suitably and effectively interface with other NAS subsystems.

#### 4.1 FAA-E-2853A TVRTM TESTS (APPENDIX A).

These tests were run by the contractor during Factory Acceptance testing and/or Site Acceptance testing and witnessed by the FAA Technical Center personnel. These tests were run to evaluate how well the LDRCL equipment met the LDRCL specification.

#### 4.2 OPERATIONAL USER'S REQUIREMENT TVRTM TESTS (APPENDIX B).

##### 4.2.1 NAS System Level Tests.

These tests were run to evaluate that the LDRCL equipment can suitably and effectively interface with other NAS subsystems. Figure 4 is a typical NAS system level block diagram of the test configuration used. The Fireberd provides digital data which simulates a user such as a radar. The Modem is a Codex 3600 which represents part of the Data Multiplexing Network (DMN) Subsystem and helps simulate the necessary connections for the LDRCL subsystem to DMN subsystem interface.

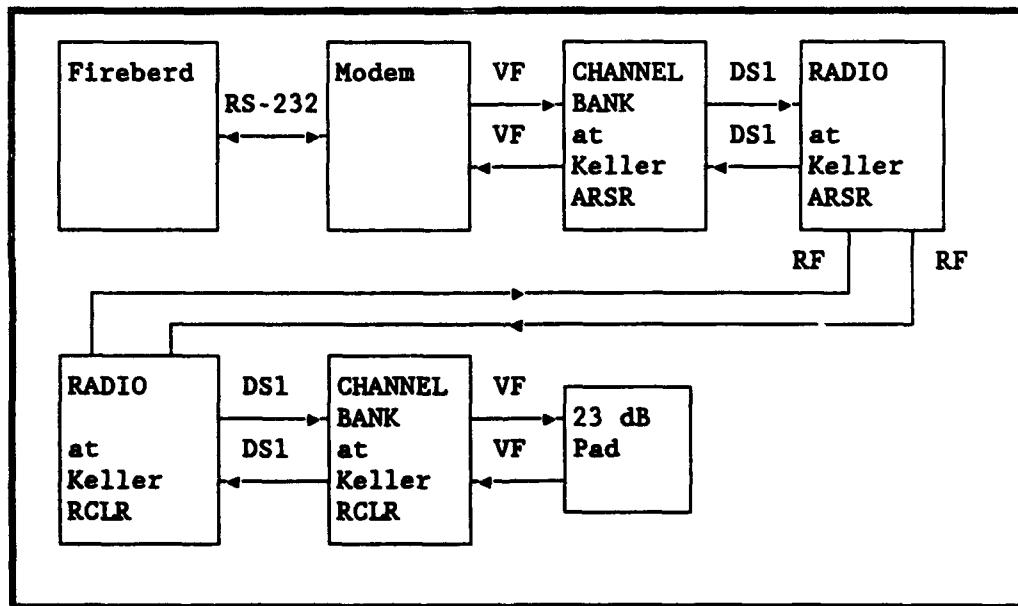


FIGURE 4. TYPICAL NAS SYSTEM BLOCK DIAGRAM

The following NAS system level test was run at the key site:

- a. AC Power Test (TVRTM test #7).

#### 4.2.2 Subsystem Level Tests.

These tests were run to see that the LDRCL subsystem met certain criteria established by the FAA Technical Center in the LDRCL OT&E Integration and Operational Test Plan. See figure 5 for a typical block diagram for a subsystem level test.

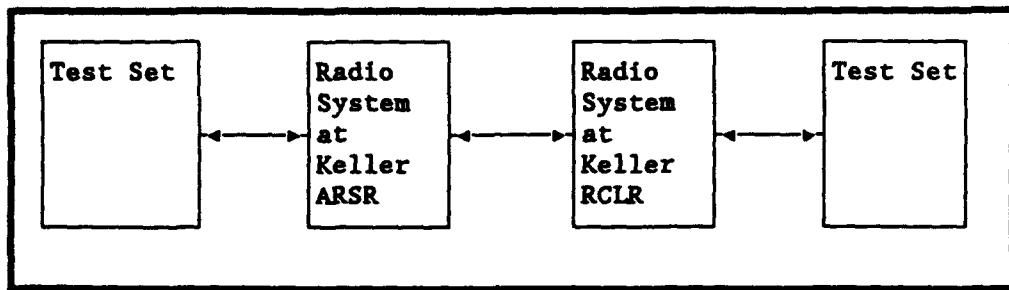


FIGURE 5. SUBSYSTEM BLOCK DIAGRAM

The following subsystem level tests were run at the key site:

- a. Crosstalk (TVRTM test #2),
- b. Maintainability Test (TVRTM test #4),
- c. LRU Removal/Replacement Test (TVRTM test #5).

#### 4.3 SYSTEM LEVEL/INTEGRATION MATRIX TESTS (APPENDIX C).

##### 4.3.1 NAS System Level Tests.

These tests were run to evaluate that the LDRCL equipment can suitably and effectively interface with other NAS subsystems. See figure 4 for a typical NAS system level block diagram of the test configuration used. The Fireberd provides digital data which simulates a user such as a radar. The Modem is a Codex 3600 which represents part of the DMN subsystem and helps simulate the necessary connections for the LDRCL subsystem to DMN subsystem interface.

The following NAS system level tests were run at the key site:

- a. Modem to LDRCL Test,
- c. Total Harmonic Distortion Test.

##### 4.3.2 Subsystem Level Tests.

These tests were run to see that the LDRCL subsystem met certain criteria established by the Program Office in the MTP. Figure 5 is a typical block diagram for a subsystem level test.

The following subsystem level tests were run at the key site:

- a. Envelope Delay Distortion Test,
- b. Frequency Translation and Level Test,
- c. Channel Amplitude Frequency Response Test,
- d. Phase and Jitter Test,
- e. Voice Frequency Performance Test,
- f. Silent Failure Test.

## 5. TEST RESULTS.

### 5.1 TEST RESULTS AT THE FAA TECHNICAL CENTER.

#### 5.1.1 Operational User's Requirements TVRTM Test Results (Appendix B).

Eleven test requirements are specified in the FAA Master Test Plan Operational User's Requirements TVRTM (also contained in appendix B of this document). Out of these, seven were requirements to be tested by the FAA Technical Center and four were requirements to be tested by the shakedown test team. Out of the seven tests tested at the FAA Technical Center, six passed and one failed. The one that failed does not affect the operational performance of the radio and is considered a minor deficiency. The test that failed was the EMI/RFI test. The equipment that was affected by the radiated field was the alarm monitoring system and this was at a very high field strength which normally would not be encountered in the LDRCL environment.

#### 5.1.2 System Level Requirements Verification Test Results (Appendix C).

Eleven test requirements are listed in the system level/Integration Test Matrix contained in appendix C of this report. Out of the 11 tests, 8 tests passed completely. One of the tests that passed at the FAA Technical Center did fail at the key site. It was the silent failure test. The system at the FAA Technical Center is not equipped with a battery backup. The system at the key site contains a silent failure associated with the battery system. Three tests that did not completely pass the specification, but do not affect the operational performance of the system, are considered minor deficiencies. For more details, see the notes associated with the tests in appendix C.

## 5.2 OT&E INTEGRATION TEST RESULTS.

### 5.2.1 FAA-E-2853A TVRTM TEST RESULTS.

Fifty-nine subsystem level test requirements are specified for the LDRCL 23-GHz digital radio system (appendix A). Forty-two passed, 8 failed, 8 could not be completely verified, and 1 was not tested. (See the notes associated with the TVRTM.) The tests that did fail, failed because the equipment selected was NDI equipment which did not entirely meet the LDRCL specifications. The failed tests were considered as noncritical to the actual performance of the radio system and are considered minor deficiencies which do not affect the operational performance of the radio system.

### 5.2.2 Operational User's Requirements TVRTM Test Results.

At the OT&E key site there were 11 Operational User's Requirements Tests (appendix B) which could be performed on the 23-GHz digital radio system. Three requirements were successfully verified at the key site. Three tests could not be verified at the key site as the system was not connected into the RCL as required. One test, the RFI test, could not be run at the key site as it would interfere with all microwave transmissions in the area, and four tests will be verified during OT&E Shakedown tests. The tests that could not be performed at the key site, were performed at the FAA Technical Center (see section 5.1.)

### 5.2.3 System Level/Integration Matrix Test Results.

Eleven test requirements are listed in the system level/Integration Test Matrix contained in appendix C of this report. Out of the 11 tests, 6 tests passed completely. Three tests did not completely pass the specifications and are considered minor deficiencies which do not affect the operational performance of the system. One test, the silent failure test, completely failed. This is considered a moderate deficiency which needs to be corrected. One test was not run at the key site. For more details, see the notes associated with the tests in appendix C.

## 6. CONCLUSIONS.

### 6.1 TEST CONCLUSIONS AT THE FAA TECHNICAL CENTER.

#### 6.1.1 Operational User's Requirements Test Verification Requirements Traceability Matrix (TVRTM) Test Conclusions.

Based upon the test results obtained, the conclusion for the requirements that failed are as follows:

- a. Verify that the Low Density Radio Communications Link (LDRCL) is not affected by electromagnetic radiation and does not affect other Federal Aviation Administration (FAA) systems with Electromagnetic Interference (EMI).

This requirement was not met. The Westronic Alarm System experienced interference problems in the presence of a radiated field. This problem is not satisfactory and should be corrected.

#### 6.1.2 System Level/Integration Test Matrix Test Conclusions.

Based upon the test results obtained, the conclusions for the requirements that failed are as follows:

- a. Modem to LDRCL Interface Test.

Tests at the FAA Technical Center indicate that when a Codex 3600 modem operates at speeds of 19,200 and 9,600 bits per second (bps) over 4-wire Ear and Mouth (E&M) cards, 4-wire E&M/Extended Range (ER) cards, or Transmission Only Extended Range (TO/ER) cards, errors are produced. The Bit Error Rates (BER) are in the range 2E-07 and 2E-08. This is satisfactory.

b. Total Harmonic Distortion (THD).

The 1 DS1 system tested in Keller, Texas, without THD filters does not meet the critical bus criteria contained in Order 6950.2C. The 8 DS1 configuration with THD filters at the FAA Technical Center does meet this requirement. Therefore, it is concluded that to meet the current THD requirement for the critical bus, THD filters are required. For noncritical AC power bus installations, THD filters are not required. This is satisfactory.

Both the 1 DS1 system without THD filters and the 8 DS1 system with THD filters pass specification FAA-G-2100F, Electronic Equipment, General Requirements Specification. This is satisfactory for noncritical bus installations.

c. In-rush Current.

The 8 DS1 radio system at the FAA Technical Center does not meet the critical bus criteria contained in Order 6950.2C. Specifically, it is the time it takes for the in-rush current to return to 110 percent of the normal value. The requirement is 8 milliseconds (ms). LDRCL's value is approximately 350 to 400 ms. This is not satisfactory for critical alternating current (A/C) bus installations and should be corrected.

The 8 DS1 radio does meet the in-rush requirements contained in specification FAA-G-2100F, Electronic Equipment, General Requirements Specification. This is satisfactory for noncritical bus installations.

6.2 OPERATIONAL TEST AND EVALUATION (OT&E) INTEGRATION TEST CONCLUSIONS.

6.2.1 FAA-E-2853A TVRTM Test Conclusions.

Based upon the test results obtained, the conclusions for the requirements that failed are as follows:

a. Specification Paragraph 3.2.1 General. All performance requirements specified shall be met when the equipment is assembled into a system in the configuration that will be installed for field operation.

This requirement was not met. This nondevelopmental item (NDI) equipment does not completely meet all the requirements specified. This is still satisfactory as the equipment will accomplish its mission in the National Airspace System (NAS).

b. Specification Paragraph 3.2.3, Equipment Configuration. For a digital system, the failure sensing shall be initiated by the system BER. The threshold level for switching operation shall be adjustable and normally set to operate at a BER of 10E-06.

The equipment does not switch on BER. The equipment switches on the automated gain control (AGC) voltage level. The switch point is adjustable and can be set to switch at a level that would approximate a 10E-06 BER which is satisfactory.

c. Specification Paragraph 3.2.4, Radio Frequency Coupler. A radio frequency (RF) coupler shall be provided that will present a minimum of 30 decibel (dB) of forward attenuation to the RF signal for testing purposes.

This equipment has a coupler built into the transmit waveguide path. This coupler is a precision 20-dB coupler which is not the 30-dB coupler specified. Since this is NDI equipment and the coupler is only used for monitoring purposes, this is satisfactory. Also, it does not affect the operational performance of the radio.

d. Specification 3.2.8, Receiver/Combiner Switch. The receiver/combiner switch shall not cause interruptions or transients which may degrade the signal. Level changes due to automatic combiner/switch action shall not cause loss of digital data.

The radio was not designed with hitless switching. Therefore, during a receiver or transmitter switch, the radio will experience a loss of data. If the path analysis is done correctly, this should happen less than 56 minutes per year. This is satisfactory.

e. Specification 3.3.13.5.1, Narrowband Digital Mux Configuration. As an option, a narrowband digital multiplexing configuration shall be provided which is capable of multiplexing one DS-1 channel with occupied bandwidth not to exceed 1.6 megahertz (MHz).

The radio's bandwidth for one DS-1 radio is 7 MHz, not the 1.6 MHz specified. This means that we may not be able to use this radio in areas that have a congested 23-gigahertz (GHz) frequency band. This is acceptable as we still have uses for the radio in noncongested areas and other LDRCL radios can be used in the area that have a congested 23-GHz frequency band.

f. Specification Paragraph 3.8.1.1, Battery Protection. A Low Voltage Load Disconnect (LVLD) unit shall be provided that is capable of removing the batteries from the load when a predetermined cell voltage limit has been reached thus preventing damage to the battery bank due to excessive cellular discharge (normally 1.75 volts per cell). The LVLD shall also be equipped for remote control operation that permits control via the LDRCL alarm monitoring and control subsystem. A feature shall be incorporated that allows local and remote override of the switch function. Reset of the switch shall be automatic when the battery compliment recharges to normal operational voltage.

The automatic reset of switch after the batteries are charged to normal operating voltages is not incorporated. Switch resets once alternating current (A/C) power is restored to power supplies. This is satisfactory as most NDI radio systems are designed this way.

g. Specification Paragraph 4.3, System Tests. The contractor shall conduct on the first system of each type ordered, factory system end-to-end performance acceptance tests, i.e., the tests required to demonstrate to the government that the system meets the requirements as specified. The tests shall demonstrate that all equipment is operating within the normal operating tolerances as stated in the equipment documentation.

The equipment does not meet all the requirements as specified because it is NDI equipment. All the specification requirements that are not met will not affect the operational performance of the system. For NDI equipment, this is satisfactory.

h. Specification Paragraph 4.4, Field System Tests. When site installation of a microwave system is ordered by the government, the contractor shall conduct field system end-to-end performance acceptance tests, i.e., the tests required to demonstrate to the government that the system is installed and operating in accordance with the requirements as specified. The tests shall demonstrate that all equipment is operating within the normal operating tolerances as stated in the equipment documentation.

The equipment does not meet all the requirements as specified because it is NDI equipment. All the specification requirements that are not met will not affect the operational performance of the system. For NDI equipment, this is satisfactory.

#### 6.2.2 Operational User's Requirements TVRTM Test Conclusions.

All the tests that could be tested at the key site were successfully completed. For additional conclusions on testing associated with this matrix, see section 6.1.1.

#### 6.2.3 System Level/Integration Matrix Test Conclusions.

All testing associated with this matrix was successfully completed with the exception of the silent failure test. This test was not successfully completed and additional work is necessary to correct the problem encountered during this test.

### 7. RECOMMENDATIONS.

Based on all test results, it is recommended that the 23-gigahertz (GHz) Low Density Radio Communications Link (LDRCL) digital radio system be deployed at this time under the following conditions:

a. The following two items have not been tested and may not be deployed until successful Operational Test and Evaluation (OT&E) testing has been performed.

1. Seismic Rack

2. 4-Wire Ear and Mouth (E&M)/Private Line Automatic Ringdown (PLAR)/Extended Range (ER) voice card

b. A ferrite or Radio Frequency Interference (RFI) filtering will be added to the Westronic WS2000 alarm system input power lines during site installation as indicated in a memo sent to the Federal Aviation Administration (FAA) Technical Center by the program office.

c. A switch or some kind of sensing circuit will be added to the Low Voltage Battery Disconnect relay to indicate when the relay has failed.

d. For critical alternating current (A/C) power bus installations, Total Harmonic Distortion (THD) filters will be installed and a waiver must be granted that releases LDRCL from the requirement that the duration of the in-rush current shall not exceed 8 milliseconds (ms). (Return to 110 percent of its normal value.) LDRCL exceeds this requirement. For noncritical AC power bus installations, THD filters are not required but the installation of the filters would be beneficial to other equipment connected to the bus. The regions can decide for themselves if they want to install THD filters at these locations.

## 8. ACRONYMS AND ABBREVIATIONS.

A/C	alternating current
AGC	Automatic Gain Control
ARSR	Air Route Surveillance Radar
ARTCC	Air Route Traffic Control Center
ASR	Airport Surveillance Radar
ATCT	Air Traffic Control Tower
BER	Bit Error Rate
bps	bits per second
COTS	Commercial Off-the-Shelf
dB	Decibel
DMN	Data Multiplexing Network
E&M	Ear and Mouth
ECP	Engineering Change Proposal
EMI	Electromagnetic Interference
ER	Extended Range
FAA	Federal Aviation Administration
GHz	gigahertz
LDRCL	Low Density Radio Communications Link
LRU	Line Replaceable Unit
LVBD	Low Voltage Battery Disconnect
LVLD	Low Voltage Load Disconnect
MHz	megahertz
ms	millisecond
MTP	Master Test Plan
NAS	National Airspace System
NDI	Nondevelopmental Item
OT&E	Operational Test and Evaluation
PCP	Power Conversion Products
PLAR	Private Line Automatic Ringdown
RCAG	Remote Air to Ground
RCL	Radio Communications Link
RCLR	Radio Communications Link Repeater
RF	Radio Frequency
RFI	Radio Frequency Interference
TIMS	Transmission Impairment Measurement Set
THD	Total Harmonic Distortion
TO/ER	Transmission Only Extended Range
TOR	Technical Onsite Representative
TRACON	Terminal Radar Approach Control
TVRTM	Test Verification Requirements Traceability Matrix

**APPENDIX A**

**FAA-E-2853A**

**TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX (TVRTM)**

Paragraph No.	Requirement Description	Verification Method			Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	Pass/ Fail	
3.1.2.1	Duty Cycle	A	X	*	N/A	P	
3.1.2.2	Ambient Temperature	A	X	*	N/A	P	
3.1.2.3	Relative Humidity	A	X	*	N/A	P	
3.1.2.4	Power	A	X	*	N/A	P	
3.1.2.5	Racks	I	X	*	N/A	N/V	1
3.1.2.7	Solid State	I	I	*	N/T	P	
3.1.2.8	Accessibility	I	I	*	N/T	P	
3.1.2.9	Transient Protection	I	I	N/T	*	P	
3.1.2.10	Finishes	I	I	*	N/T	P	
3.1.2.11	Cooling	I	I	*	N/T	P	
3.1.2.12	Interchangeability	A	X	*	N/A	P	
3.1.2.13	Special Equipment	I	I	*	N/T	P	

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
 Notes:  
 \* - Verification Method Conducted.  
 P - Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable,  
 N/V - Not Completely Verified.  
 1 - Paragraph Passed with the exception of the seismic rack which was not available.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
3.2.1	General	T	X	*	N/A	F 2
3.2.2.1	Spectrum Design Req'ments	X	I	N/A	N/T	N/V 3
3.2.2.2	Frequency and Antenna Polarization	D	I	*	N/T	P
3.2.3	Equipment Configuration	T	T	N/T	N/T	F 4
3.2.4	Radio Frequency Coupler	I	I	*	N/T	F 5
3.2.5	Radio Freq Connectors	I	I	*	N/T	P
3.2.6	Antennas	X	I	N/A	*	P
3.2.7	Transmission Lines	X	I	N/A	*	P
3.2.8	Receiver/Combiner Switch	T	T	*	N/T	F 6

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable

Notes:

- \* - Verification Method Conducted.
- P - Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable, N/V = Not Completely Verified.
- 2 - All performance requirements were not met.
- 3 - Frequencies are ordered by the Program Office under the advice of the FAA Frequency Management section.
- 4 - Failure sensing is not initiated by BER. Threshold for switching is adjustable but is based on AGC voltage, not BER.
- 5 - Coupler has only 20 dB forward attenuation, not the 30 dB specified.
- 6 - During a receiver or transmitter switch the system produced errors.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O Pass/ Fail
		Subsystem Level	System Level	FAT	Key Site	
3.2.9	Digital Multiplexing Equipment	T	T	*	*	N/V 7
3.2.9.1	Redundant Configuration	T	T	*	N/T P	
3.2.9.2	Monitor and Test Capability	T	T	*	N/T P	
3.2.10.1	General	D	D	*	N/T P	
3.2.10.2	Auxiliary Functions	D	D	*	N/T P	
3.2.11	Jackfields	I	I	*	N/T P	
3.2.12	RF Splitter	I	I	*	N/T P	
3.2.13	Line Conditioning Equipment	T	T	N/T	N/T	N/T 8

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
 Notes:

- \* - Verification Method Conducted.
- P - Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable.
- N/V - Not Completely Verified.
- 7 - Paragraph Passed with the exception of the 4-wire EMM/PLAR/ER which was not available for test.
- 8 - Equipment was not available for test.

Paragraph No.	Requirement Description	Verification Method			Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	Pass/ Fail	
3.3.13.5	Digital Multiplex Equipment	T	T	*	N/T	P	
3.3.13.5.1	Narrow Band Digital Mux Configuration	T	T	N/T	*	F	9
3.5.1	Frequencies of operation for 23 GHz equipment	T	T	*	*	P	
3.5.2	System Gain/Receiver Threshold	T	T	*	*	P	
3.5.3	Transmitter Frequency Stability	T	T	*	*	P	
3.5.4	Equipment Packaging	I	I	*	*	P	
3.5.6	Path Reliability	X	T	N/T	*	P	
3.6	Remote Monitoring/Sensing	I	I	*	N/T	N/V	10

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
Notes:  
\* = Verification Method Conducted.  
P = Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable,  
N/V = Not Completely Verified.

- 09 - Bandwidth is 7 MHz not the 1.6 MHz specified.
- 10 - The RCL alarm system was not connected to the LDRCL alarm system in Keller, Texas; therefore, the LDRCL alarms could not be tested back to the RCL alarm system. (ACORN). The LDRCL alarm system to RCL alarm system interface was successfully tested at the FAA Technical Center.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
3.6.1	Reported Alarms	T	T	*	*	P
3.6.2	Alarm Indication	T	T	*	*	P
3.6.2.1	Alarm Interfaces with RCL system (TABS)	T	T	N/T	*	P
3.6.3	Remote Controls	T	T	*	*	P
3.7.1	Reliability	A	X	*	N/A	P
3.7.2	Maintainability	A	X	*	N/A	P
3.7.3	Availability	A	X	*	N/A	P
3.8.1	Batteries	X	I	N/A	*	P
3.8.1.1	Battery Protection	T	T	N/T	*	F 11
3.8.2	Battery Charger	T	X	N/T	*	P
3.8.2.1	Optional Battery Charger	X	T	N/A	*	P

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
 Notes:  
 \* = Verification Method Conducted.

P = Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable,  
 N/V = Not Completely Verified.

11 - Remote control of the LVBD does not work. Auto reset does not work as per specification.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
3.8.4	Towers	X	D	N/A	N/T	N/V 12
3.8.4.1	Obstruction Lights	A	I	*	N/T	P
3.8.5	Antenna Mounts	A	I	*	N/T	P
3.8.6	Grounding System	X	T	N/A	*	P
3.9.2	Instruction Books	X	I	N/A	N/T	N/V
3.10.2.1	Site Spares	X	I	N/A	N/T	N/V 13
3.10.2.2	Depot Parts - Peculiar	X	I	N/A	N/T	N/V
4.3	System Tests	T	X	*	N/A	N/V 13
4.4	Field System Tests	X	T	N/A	*	F 14
5.0	Preparation for Delivery	I	X	*	N/A	P

**Verification Method:** T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
**Notes:**

- \* = Verification Method Conducted.
- P = Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable, N/V = Not Completely Verified.
- 12 - There were no new towers at this key site. This requirement did successfully pass at the first key site for the 1.8 GHz digital radio.
- 13 - Not tested by ACW, AOS responsibility.
- 14 - The equipment does not meet all the requirements as specified, and does not operate within the normal operating tolerances as stated in the equipment documentation.

Paragraph No.	Requirement Description	Verification Method		Test Location		N O T E
		Subsystem Level	System Level	FAT	Key Site	
6.0	Preparation for Installation	X	I	N/A	*	P

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable

Notes:

\* = Verification Method Conducted.

P = Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable,  
N/V = Not Completely Verified.

**APPENDIX B**

**OPERATIONAL USER'S REQUIREMENTS  
TEST VERIFICATION REQUIREMENTS TRACEABILITY MATRIX (TVRTM)**

Requirement Description	Verification Method			Test Location		Notes
	Integration Level	Shakedown Level	FAATC	Key Site		
1. Verify that the audio quality of any circuit does not become degraded, and that there is no detectable change in voice quality/level as the LDRCL is accessed by signals to and from the RCL links.	D	X	*	N/T	P	
2. Verify that crosstalk is not detectable under maximum loading of the LDRCL paths.	D	X	*	*	P	
3. Verify that the alarm indicators function properly under electrical transients caused by commercial power changes.	D	X	*	N/T	P	
4. Verify that after system failure in LDRCL, the entire path can be restored in 30 minutes. (Maintainability).	D	X	*	*	P	

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
 Notes:  
 \* = Verification Method Conducted  
 P = Passed, Meets requirement without comment, N/T = Not Tested, N/A = Not Applicable

Requirement Description	Verification Method		Test Location		Notes
	Integration Level	Shakedown Level	FAATC	Key Site	
5. Verify that the removal\replacement of any line replaceable unit (LRU) does not affect the normal operation of the LDRCL.	D	X	*	*	P
6. Verify that adequate spare parts exist at each site to support urgent repairs to the LDRCL.	X	D	N/T	*	1
7. Verify that the LDRCL can be integrated with existing FAA facility Power and environmental systems with little or no impact on normal operations.	X	D	N/T	*	1
8. Verify that the LDRCL can protect itself from the effects of power outages, fluctuations and harmful transients.	X	D	N/T	*	1

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
 Notes:  
 \* - Verification Method Conducted  
 P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable

1 - AOS - 200 responsibility, see shakedown report

Requirement Description	Verification Method		Test Location		Notes
	Integration Level	Shakedown Level	FAATC	Key Site	
9. Verify that the LDRCL, in the process of accessing the circuits of the RCL paths, will not take down any other specified, critical circuits that would not otherwise have been affected by the problem.	D	X	*	N/T	P
10. Verify by random sampling the mechanical and electrical interchangeability among assemblies, subassemblies, and LUU's that are supposed to be identical.	X	D	N/T	*	2
11. Verify that the LDRCL is not affected by electromagnetic radiation and does not affect other FAA systems with EMI	D/T	X	*	N/T	3

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable  
 Notes:

- \* - Verification Method Conducted
- P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable
- 2 - AOS-200 responsibility, see shakedown report.
- 3 - The only unit which was affected by electromagnetic interference (EMI) was the Westronic Alarms System. All the rest of the equipment was not affected by EMI.

**APPENDIX C**  
**SYSTEM LEVEL/INTEGRATION TEST MATRIX**

Test Description	Verification Method	Test Location			Notes
		System Level	Integration Level	FAATC	
1. Envelope Delay Distortion Test	T	X		*	*
2. Frequency Translation and Level Test	T	X		*	P
3. Channel Amplitude Frequency Response Test	T	X		*	P
4. Phase and Jitter Test	T	X		*	P
5. Voice Frequency Performance Test	T	X		*	P
6. Modem to LDRCL Test	X	T		*	1
7. ANMS to LDRCL Interface Test	X	T		*	N/T P
8. Degraded Operations Test	X	T		*	N/T P

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable

Notes:

- \* - Verification Method Conducted
- P - Passed, Meets requirement without comment, N/A - Not Tested, N/A - Not Applicable
- 1 - Testing the Codex Modem running at speeds of 19,200 and 9,600 bps with the 4-wire E&M, 4-wire E&M/ER and Transmission Only/Extended Range (TO/ER) cards produced Bit Error Rates of 2E-07 to 2E-08.

Test Description	Verification Method			Test Location		Notes
	System Level	Integration Level	FAATC	Key Site		
9. Total Harmonic Distortion Test	X	T	*	*	*	2
10. Inrush Current Test	T	N/T	*	N/T	*	3
11. Silent Failure Test	T	T	*	*	*	4

Verification Method: T=Test, D=Demonstration, A=Analysis, I=Inspection, X=Not Applicable

Notes:

- \* - Verification Method Conducted
- P - Passed, Meets requirement without comment, N/T - Not Tested, N/A - Not Applicable
- 2 - With Harmonic Filters, the 8 DS1 system at the FAA Technical Center passed the THD requirement in the LDRCL specification FAA-E-2853A and FAA Order 6950.2C with a THD of 4.1 percent. Without THD filters, the 1 DS1 configuration in Keller, Texas passed specification FAA-G-2100F only. "Electronic Equipment, General Requirements Specification."
- 3 - Meets Specification FAA-G-2100F. "Electronic Equipment, General Requirements Specification." Does not meet the time requirement of 8 milliseconds for the in-rush current to return to 110 percent of its steady state value for equipment connected to the critical bus as required in FAA Order 6950.2C, but as per the DRR checklist, LDRCL will go on the essential bus.
- 4 - The Low Voltage Battery Disconnect (LVBD) can fail and drop out causing the backup batteries to disconnect from the system. An alarm should be generated but is not.